

# A Tribute to George F. Pinder

*Paul T. Imhoff  
Department of Civil and Environmental Engineering  
University of Delaware  
Newark, DE 19711 USA*

*Andrew F. B. Thompson  
Environmental Science Division  
Lawrence Livermore National Laboratory  
Livermore, CA 94550 USA*

This article was submitted to  
Advances in Water Resources

U.S. Department of Energy



**February 2004**

## **DISCLAIMER**

This document was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor the University of California nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or the University of California, and shall not be used for advertising or product endorsement purposes.

This is a preprint of a paper intended for publication in a journal or proceedings. Since changes may be made before publication, this preprint is made available with the understanding that it will not be cited or reproduced without the permission of the author.

# **A Tribute to George F. Pinder**

Paul T. Imhoff  
Department of Civil and Environmental Engineering  
University of Delaware  
Newark, DE, 19711 USA

Andrew F. B. Tompson  
Environmental Sciences Division  
Lawrence Livermore National Laboratory  
Livermore, CA 94551 USA

In the fall of 2001 a Special Session was convened at the Fall Meeting of the American Geophysical Union as a tribute to George F. Pinder's contributions to groundwater modeling in the last thirty-five years. At a subsequent meeting of the editorial board of *Advances in Water Resources (AWR)*, we reflected on George's contributions to the field of groundwater hydrology and his particular contributions to *AWR*, which he co-founded in 1977 with Carlos A. Brebbia. It was at this meeting that the seed for compiling a special issue of *AWR* in honor of George's contributions was sown.

George began his academic training at the University of Western Ontario, where he received a B.Sc degree in Geology. He then moved to the University of Illinois, receiving a PhD degree in 1968 under the supervision of John Bredehoeft. It was his work with Bredehoeft where George began to make his unique contributions to groundwater hydrology. George published the first application of digital computers to the solution of groundwater models [1], a work that earned George and John Bredehoeft the Horton Award from the American Geophysical Union in 1969. This work was later followed by the development of the first widely used contaminant transport model for groundwater systems [2], for which George and John Bredehoeft received the O.E. Meinzer Award in 1975 from the Geological Society of America.

George's interest in the application of numerical methods to the solution of groundwater problems continued during his work at the United States Geological Survey (USGS) (1968-1972), where with others he published papers on computer models for salt water intrusion [3], and application of the Galerkin-finite element method to the solution of groundwater problems [4] in addition to other works.

George left the USGS in 1972 to join the Department of Civil Engineering at Princeton University, where he served on the faculty and later as chairman until 1989. George continued his research in the application of numerical methods to the solution of groundwater problems. With his students he developed multiphase flow and transport models for nonaqueous phase liquid (NAPL) contamination [5,6], conducted experiments to determine the parameters required

for constitutive models for NAPL simulators [7,8] , and applied optimization methods to groundwater remediation design [9,10] . He authored several of the first well-known texts on numerical methods and their application to water resources problems [11-13], and was a founder in 1976 of the biennial conference series now known as Computational Methods in Water Resources. It was in this period that George began to influence the careers of emerging scientists, including his own graduate students, visiting scientists, new faculty, and even chance acquaintances at the computer card reader.

Comments from Michael Celia and Lin Ferrand of Princeton University are indicative of George's influence on his students:

“George ... has always placed his graduate students above all else in importance, and always looked out for all of us, even many years after we completed our PhD's. We have many fond memories of our experiences with George, including some very memorable summer travels with George and groups of his current and former graduate students. On those travels we combined attendance at scientific conferences (where many of us presented our earliest papers), visits to colleagues at other universities, and sight-seeing.

George influenced a generation of academic hydrologists, teaching us how to teach, how to look after our own graduate students, and to respect the academy and the pursuit of knowledge. It would not be overstating the case to say that if we had more academicians like George Pinder, the world would be a much better place” [14].

A chance encounter with a student in the computer room in the Princeton Engineering Quadrangle led George to a long collaboration with William Gray, now at the University of North Carolina, who recalls:

“I met George shortly after he joined the faculty at Princeton... I was a graduate student in a different department at that time but met George at the computer card reader. We both had large trays of punch cards that we had to read into the computer. We had a lot of time to talk while the card reader devoured and mutilated our input. It was through those chance encounters that he and I began to collaborate. I enjoyed George's enthusiasm for his research, his drive, his insight, and his energy. He was very encouraging to me about my own work at a time when I needed the encouragement. After I finished my degree, I worked with George as a post-doctoral student and then on the faculty at Princeton. The good things that have happened in my career are attributable to the opportunities that George provided me when I was starting out and to his continuing support. He has been a most stimulating colleague, an outstanding mentor, and, even more importantly, a wonderful friend” [15].

Over the years, visiting scientists also benefited from their interaction with George. In particular, Joseph Botha of the University of the Free State, South Africa observes:

“I met George and his family for the first time during his month long visit to the Institute for Groundwater Studies at our University in 1977. It was therefore natural for us to work together on a numerical model for a small Karoo aquifer, which the Director of the Institute, Prof. Hodgson, was investigating at that stage—the first numerical model ever developed for an aquifer on the African continent to my knowledge. Since I obtained my PhD in theoretical nuclear physics from the University of Stellenbosch, the Director decided that I should get more involved with groundwater and arranged with George for me to spend the academic year of 1980-1981 at Princeton University. This was a visit my family and I will never forget. The visit gave me the opportunity to collaborate with George on six papers and one book and to become acquainted with some of the finest students I have ever met” [16].

In a similar vein, Ismael Herrera of the Universidad Nacional Autónoma de México notes in his contribution to this issue [17] that, as an applied mathematician, he valued George’s friendship and collaboration in the area of water resources, as it was “an invaluable stimulus” for his own academic activities.

Finally, George had a significant positive influence on many young faculty, as illustrated by comments from Peter Jaffé of Princeton University:

“Shortly after I joined Princeton’s department of Civil Engineering as an Assistant Professor in 1985, George, who was then the department’s chair, met with me and in a casual manner suggested that I should develop a research effort in bioremediation of groundwaters contaminated with chlorinated solvents. That was not an obvious research direction for me, having previously worked on pesticide transport in rivers, nutrient dynamics in lakes, and a short effort in activated sludge systems. After several discussions with George and members of his industrial affiliates program at Princeton, I embarked on research projects that addressed TCE degradation and biofouling during aquifer bioremediation. These initial projects lead to many efforts focusing first on the bioremediation of organic contaminants in groundwaters and more recently on the bioremediation of trace metals and radionuclides in groundwaters to biogeochemical dynamics in groundwaters, sediments, and wetlands. Having George as a role model, all of these research efforts were of course coupled with rigorous mathematical simulations. George was a superb mentor and remains a close friend. Many of us will argue that one of the most exciting research areas in hydrology and in environmental engineering is at the boundary with the life sciences. It is due to George’s vision and support that my and many of my students’ careers veered into that direction.” [18]

George’s influence on academia and the scientific enterprise continued when he moved to the University of Vermont in 1989. Here George served as Dean of the College of Engineering and Mathematics, Director of the Research Center for Groundwater Remediation, and Professor of Civil and Environmental Engineering as well as Mathematics. George continued his earlier research and began to influence the next generation of scientists.

This special issue contains manuscripts from a variety of individuals whom George influenced in his career. The topics represented include movement of dense NAPLs in soils, modeling of nonlinear aquifer responses to pumping, simulation of contaminant biodegradation, type curves for unsaturated soil properties, and collocation methods for numerical discretization. The variety of topics illustrates the range of influence George has had through his career. While George's primary contributions have been in the application of numerical methods to the solution of groundwater problems, George has worked – and continues to work – in other areas and has fostered the work of other scientists through his encouragement, example, and creative influence.

## **Acknowledgements**

Work on this special issue was initiated after conversations with the editorial board of *Advances in Water Resources*, with significant encouragement from the co-editors D. Andrew Barry, Cass T. Miller, and Marc Parlange. Myron B. Allen and William Gray provided their enthusiastic support and helped us contact many of George F. Pinder's former students and colleagues. Portions of this work were conducted under the auspices of the U. S. Department of Energy by the University of California, Lawrence Livermore National Laboratory (LLNL) under contract W-7405-Eng-48.

## **References**

- [1] Pinder GF, Bredehoeft JD. Application of the digital computer for aquifer evaluation. *Water Resources Research* 1968;4(5):1060–1193.
- [2] Bredehoeft JD, Pinder GF. Mass transport in flowing groundwater. *Water Resources Research* 1973;9(1):194–210.
- [3] Pinder GF, Cooper, Jr., HH. A numerical technique for calculating the transient position of the saltwater front. *Water Resources Research* 1970;6(5):875—882
- [4] Pinder GF, Frind EO. Application of Galerkin's procedure to aquifer analysis. *Water Resources Research* 1972;8 (1):108—120.
- [5] Abriola LM, Pinder GF. A multiphase approach to the modeling of porous media contamination by organic compounds, 1. Equation development. *Water Resources Research* 1985; 21(1): 11–18.
- [6] Abriola LM, Pinder GF. A multiphase approach to the modeling of porous media contamination by organic compounds, 2. Numerical simulation. *Water Resources Research* 1985; 21(1): 19–26.
- [7] Ferrand LA, Milly PCD, Pinder GF. Dual gamma attenuation for the determination of porous media saturation with respect to three fluids. *Water Resources Research* 1986;22(12):1657–1663.
- [8] Ferrand LA, Milly PCD, Pinder GF. Experimental determination of three-fluid saturation profiles in porous media. *Journal of Contaminant Hydrology* 1989; 4:373–395.
- [9] Ahlfeld DP, Mulvey JM, Pinder GF, Wood EF. Contaminated groundwater remediation design using simulation, optimization, and sensitivity theory 1. Model development. *Water Resources Research* 1988;24(3):431–441.

- [10] Ahlfeld DP, Mulvey JM, Pinder GF, Wood EF. Contaminated groundwater remediation design using simulation, optimization, and sensitivity theory 2. Analysis of a field site. *Water Resources Research* 1988;24(3):443–452.
- [11] Pinder, GF and Gray, WG. *Finite element simulation in surface and subsurface hydrology*, Academic Press, 1977.
- [12] Lapidus, L. and Pinder, GF. *Numerical solution of partial differential equations in science and engineering*, Wiley Interscience, 1982.
- [13] Huyakorn, PS and Pinder, GF. *Computational methods in subsurface flow*, Academic Press, 1983.
- [14] Celia, MA and Ferrand, LF. Personal communication. 2003.
- [15] Gray, WG. Personal communication. 2003.
- [16] Botha, JF. Personal communication. 2003.
- [17] Herrera, I., D'íaz-Viera, M. and Yates, R. Single-collocation-point methods for the advection diffusion equation, *Advances in Water resources*, this issue.
- [18] Jaffé, PR. Personal communication. 2003.